Active Humidity Control And Continuous Ventilation For Improved Air Quality In Schools

Charlene W. Bayer

Robert J. Hendry

Amy Cook

Chris Downing

Sidney C. Crow

Stephanie Hagen

John C. Fischer

GTRI

Introduction

- Investigation into the impact of active humidity control & continuous ventilation on school IAQ
- Desiccant-cooling technologies targeted
- Meets US DOE goal of improving energy efficiency and helps to dispel belief that desiccant dehumidification systems are too costly

Project Objectives

1. Measure the importance of humidity control & continuous ventilation
2. Develop baseline IAQ data for schools in hot & humid climates
3. Provide data & recommendations for HVAC designs for improved schools IAQ
4. Document role of desiccant technologies to actively control humidity in schools
5. Provide data for school systems to specify the use of desiccant technology

GTRI

Project Team

Georgia Tech Research Institute

- Charlene Bayer (PI)
- Bob Hendry (sampling)
- Amy Cook (analytical analysis)
- Chris Downing (mechanical engineer – energy efficiency)

Georgia State University

- Sidney Crow (microbiologist)
- Stephanie Hagen (microbiological sampling & analysis)

Semco Inc.

- John Fischer (mechanical engineer – desiccant systems consultant & energy efficiency)

GTRI

Technical Approach

1. **Literature review of school IAQ**
2. **Field investigation of IAQ in 10 non-complaint Georgia schools**
   a. Matched pairs of schools with conventional HVAC systems and schools with desiccant cooling HVAC systems
   b. Continuous monitors placed in each school for CO_2, temperature, and relative humidity for approximately one year
   c. Diffusion VOC samplers in classrooms continuously for one year, changed approximately every 30 days.
   d. Active samples collected four to six times

GTRI

Active Monitoring Parameters

1. VOCs
2. Particles
3. Bioaerosols
4. Aldehydes & ketones
5. CO_2
6. CO
7. NO_2
8. Temperature
9. Relative humidity
10. Air change rate

GTRI

Continuous Monitoring

Continuous monitor placed in breathing zone in one classroom of each school measuring temperature, relative humidity, and CO_2

Diffusion tubes for VOCs placed in the breathing zone in one classroom in each school & changed approximately every 30 days.

HVAC System Designs

Outdoor Air & Exhaust Ducted Directly into Space

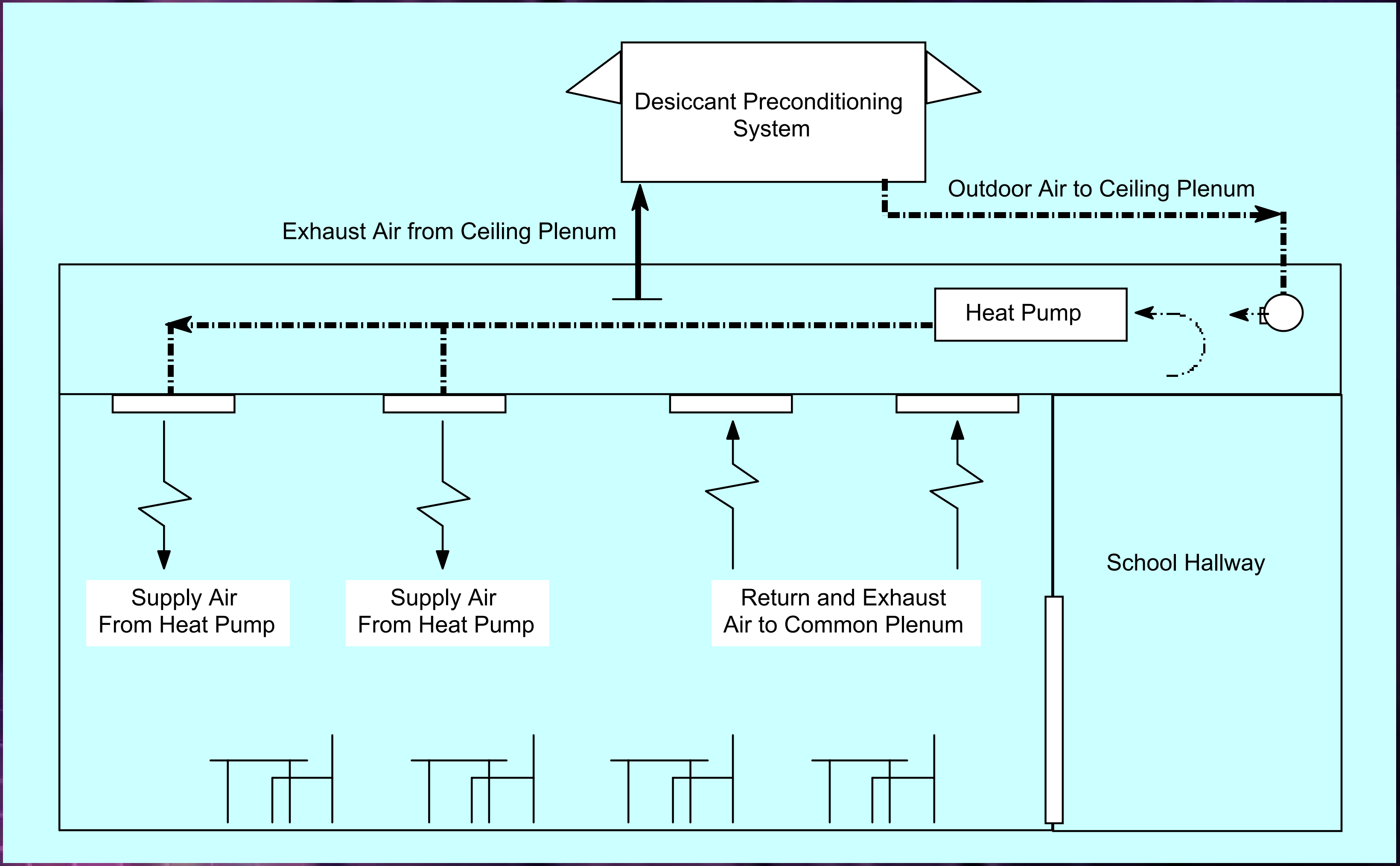
Outdoor Air & Exhaust Ducted to Heat Pump Return Duct

Outdoor Air & Exhaust Ducted to Common Return Plenum

Outdoor Air Ducted to Heat Pumps, No Exhaust Air Path

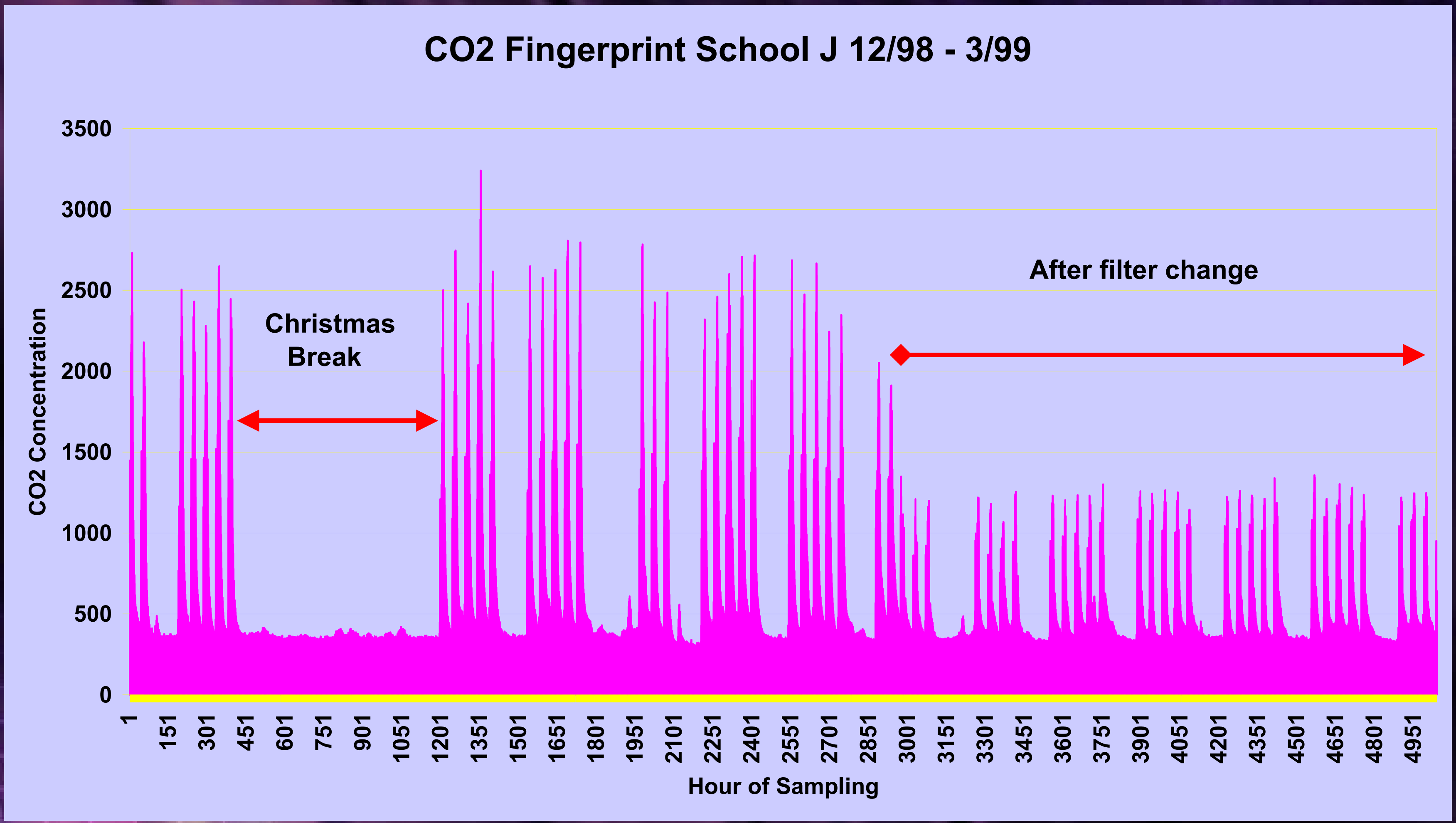
HVAC System Diagram

Outdoor Air & Exhaust Ducted to Common Return Plenum



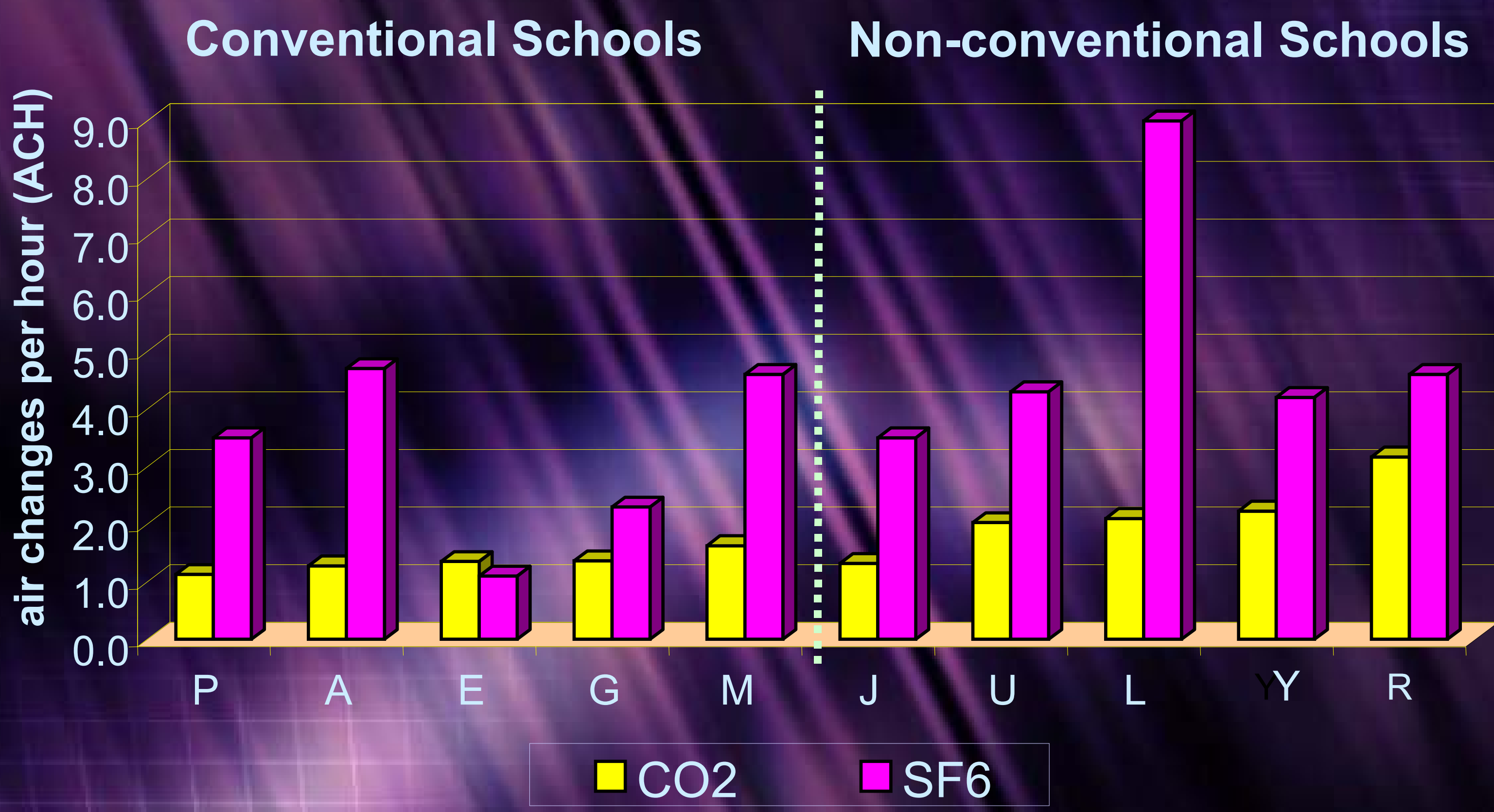
HVAC System

Outdoor Air & Exhaust Ducted to Common Return Plenum



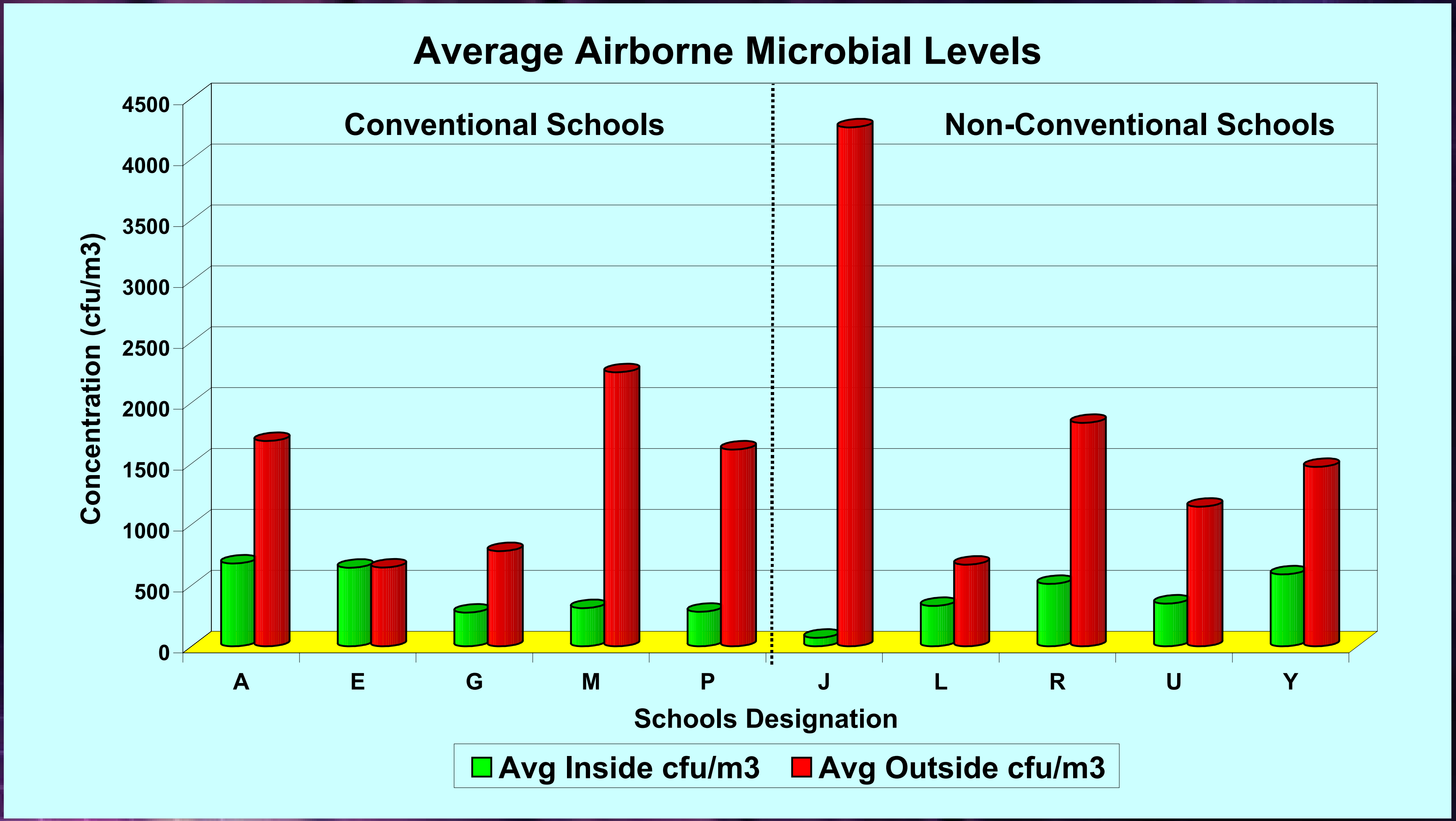
GTRI

Air Change Rate Measurement



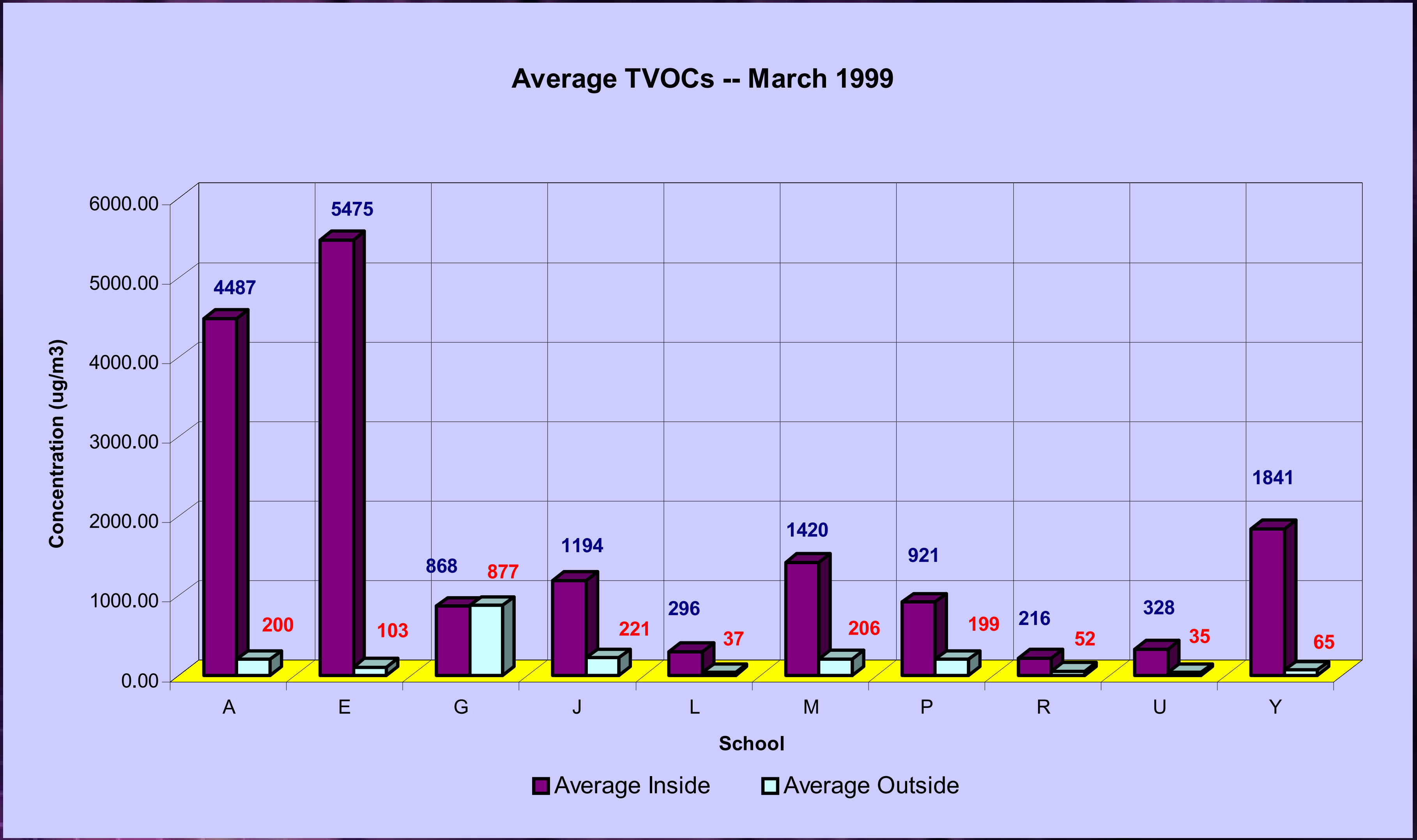
GTRI

Average Airborne Microbial Levels



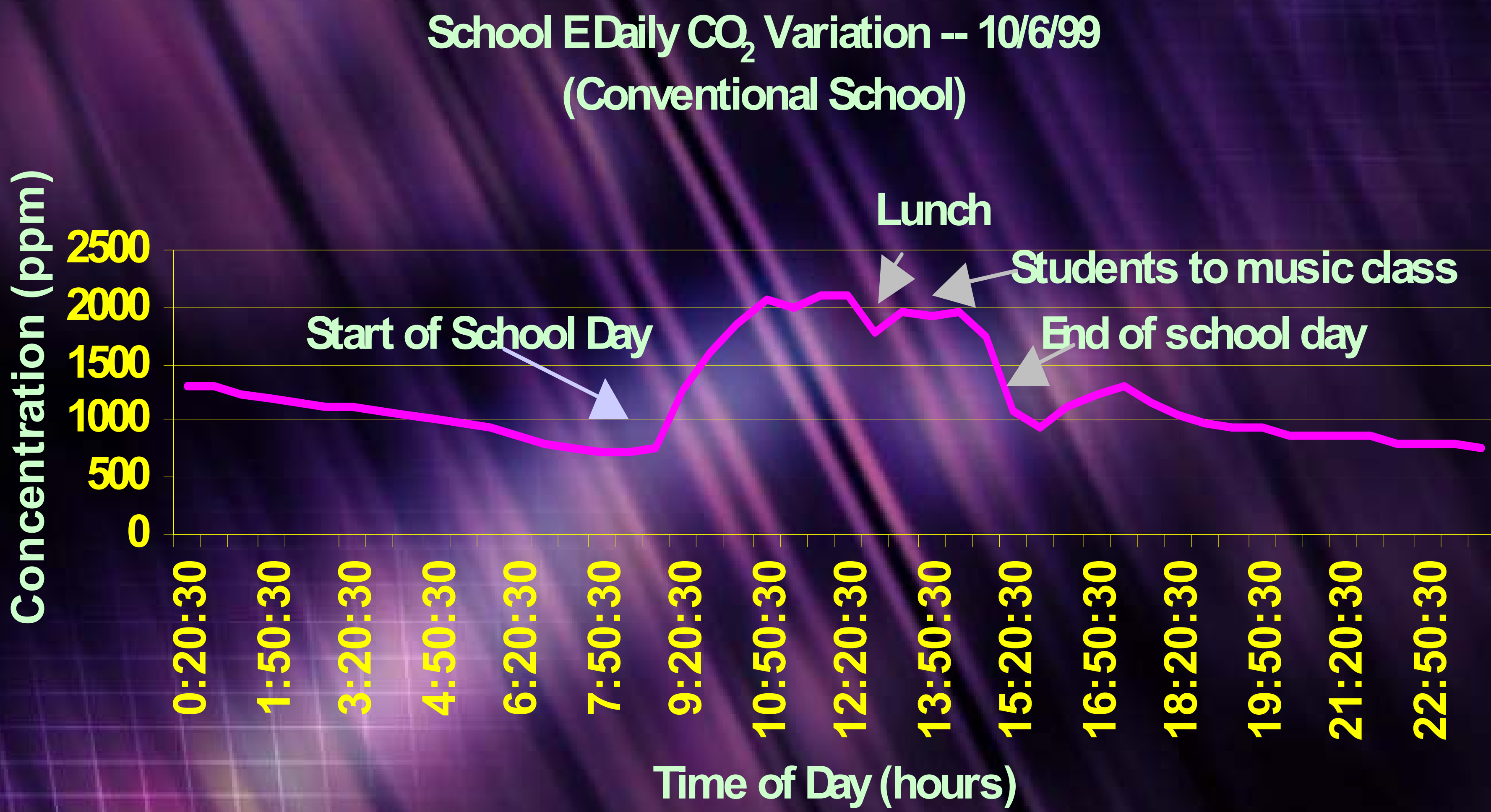
GTRI

March TVOC Levels



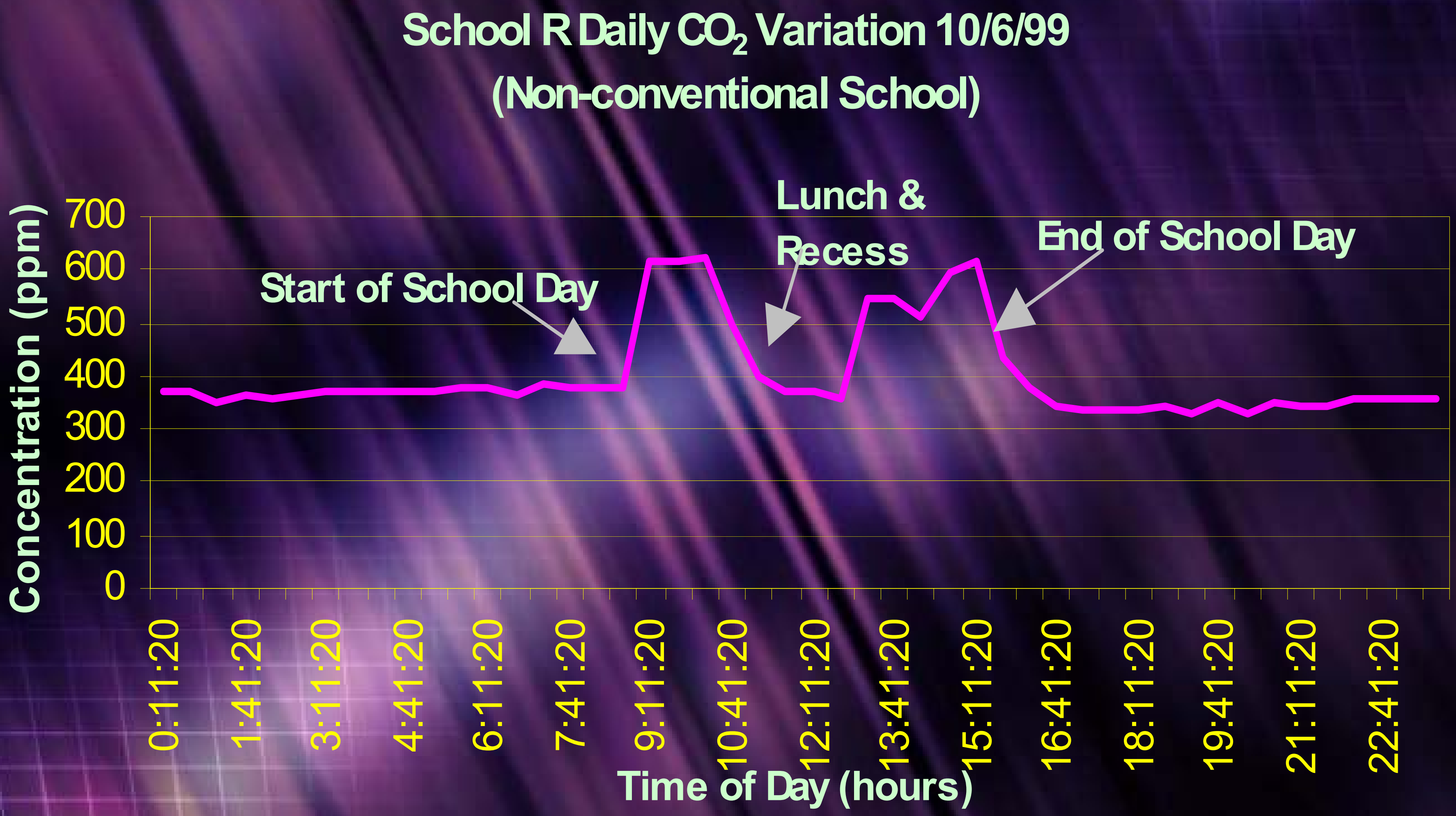
GTRI

Daily CO_2 Variation



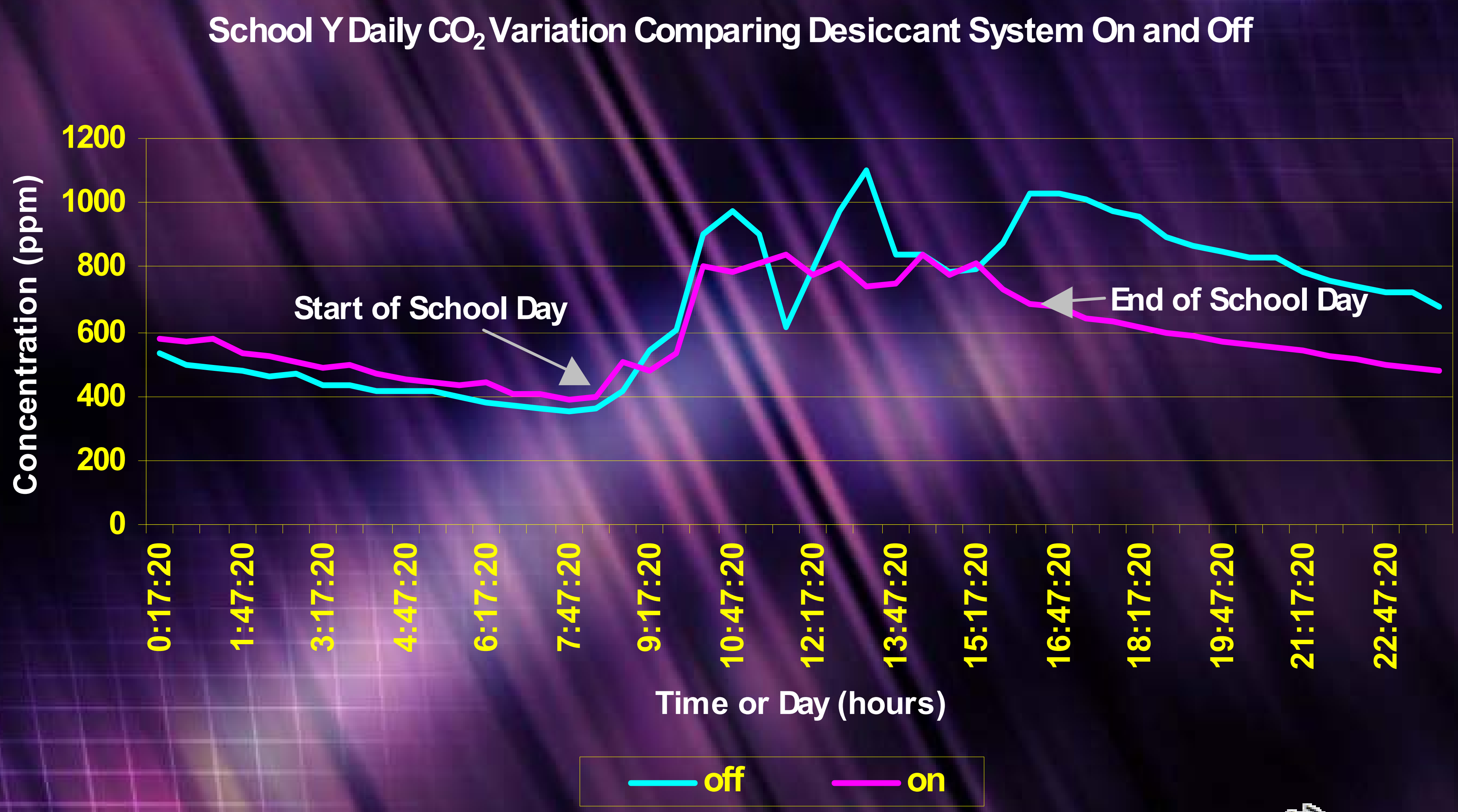
GTRI

Daily CO_2 Variation

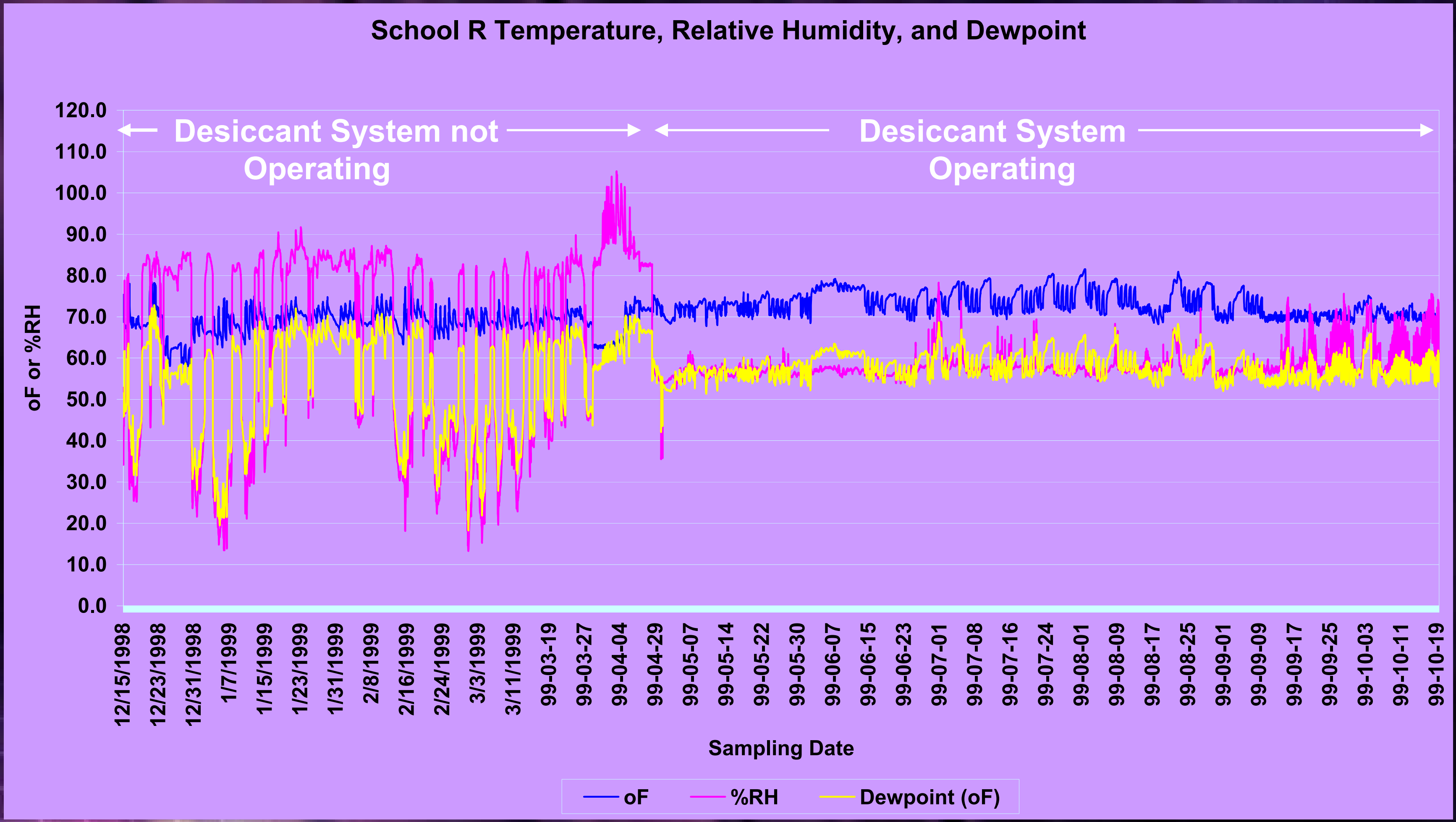


GTRI

Daily CO_2 Variation

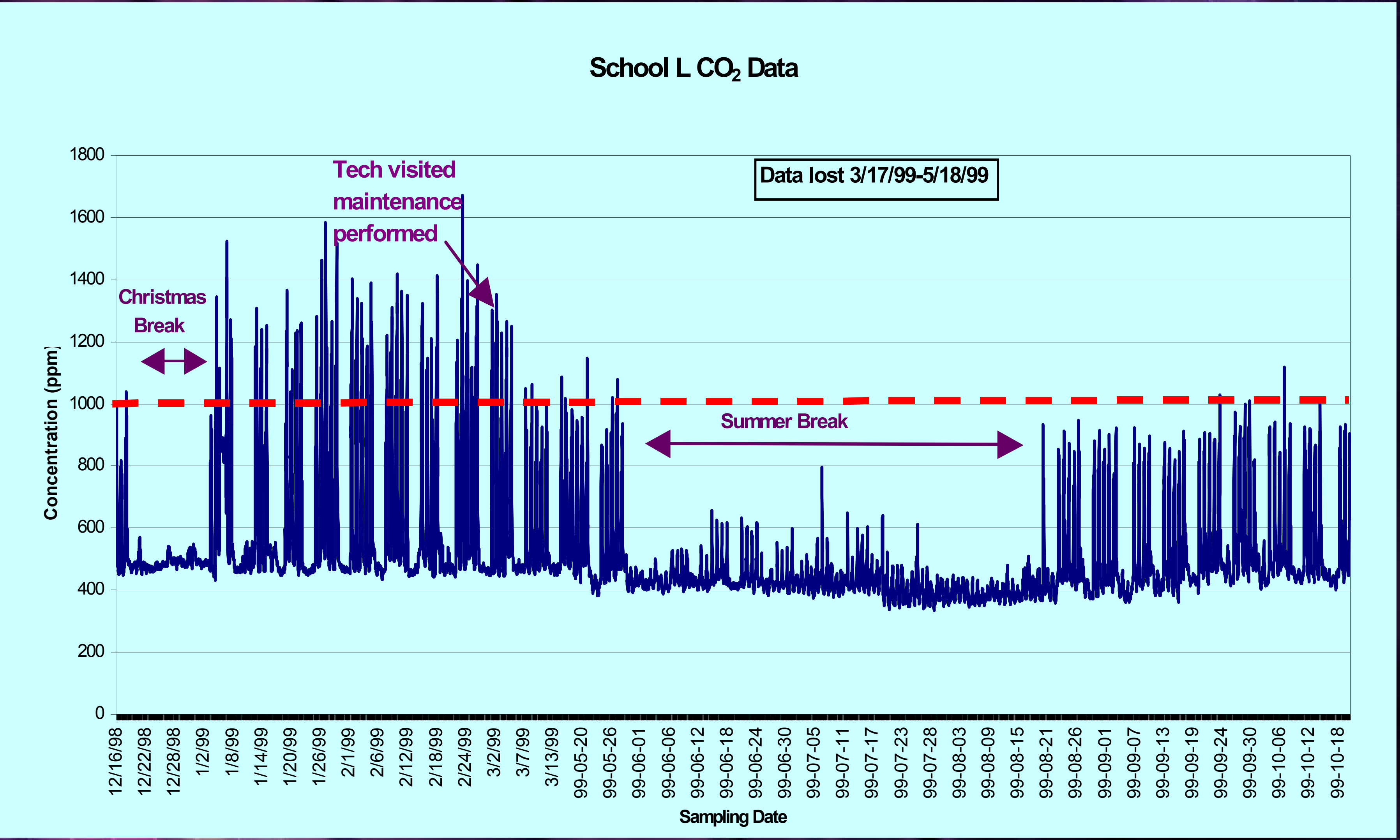


Humidity Variation with & without Desiccant System Operating



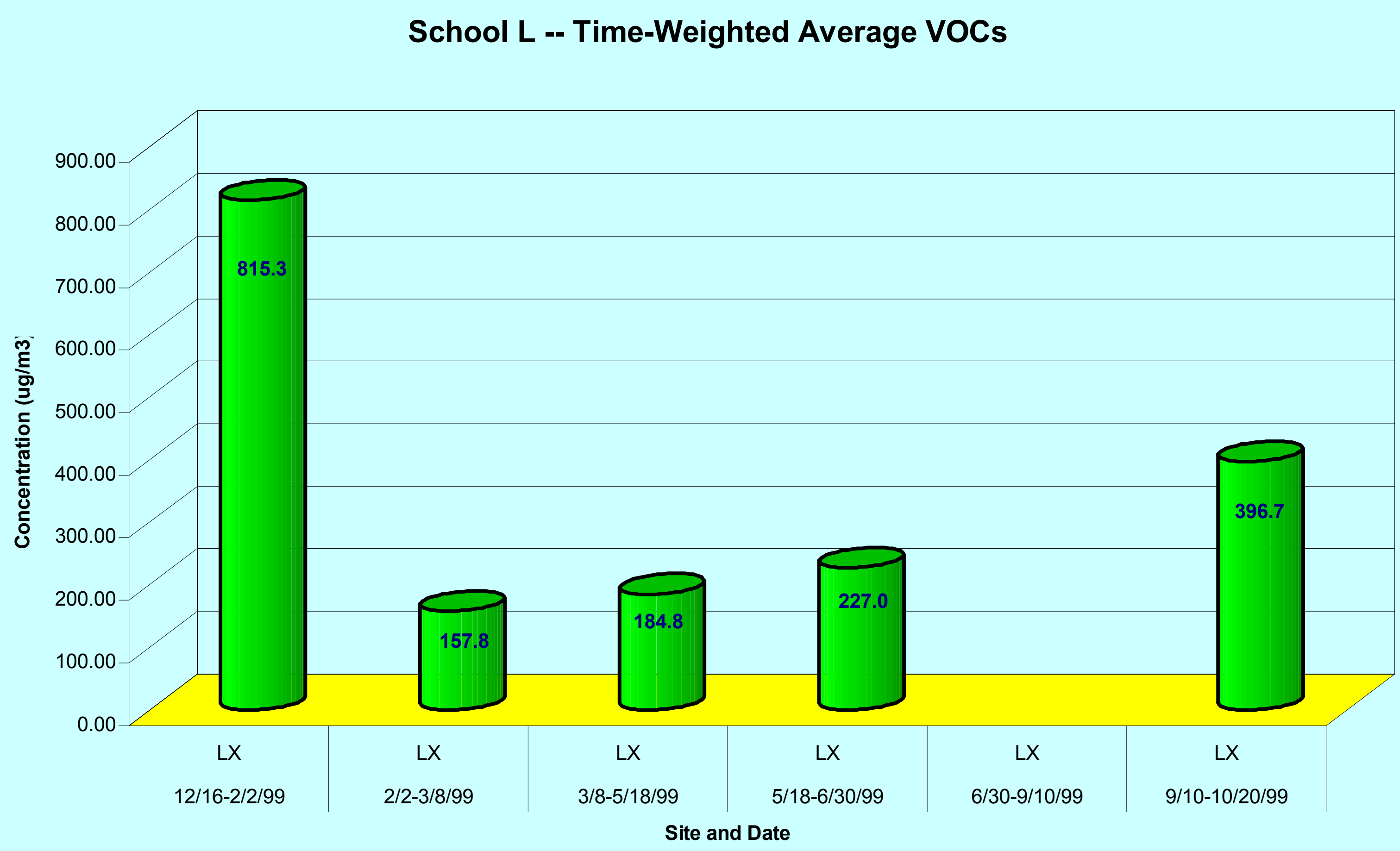
GTRI

CO_2 With & Without Desiccant Operating



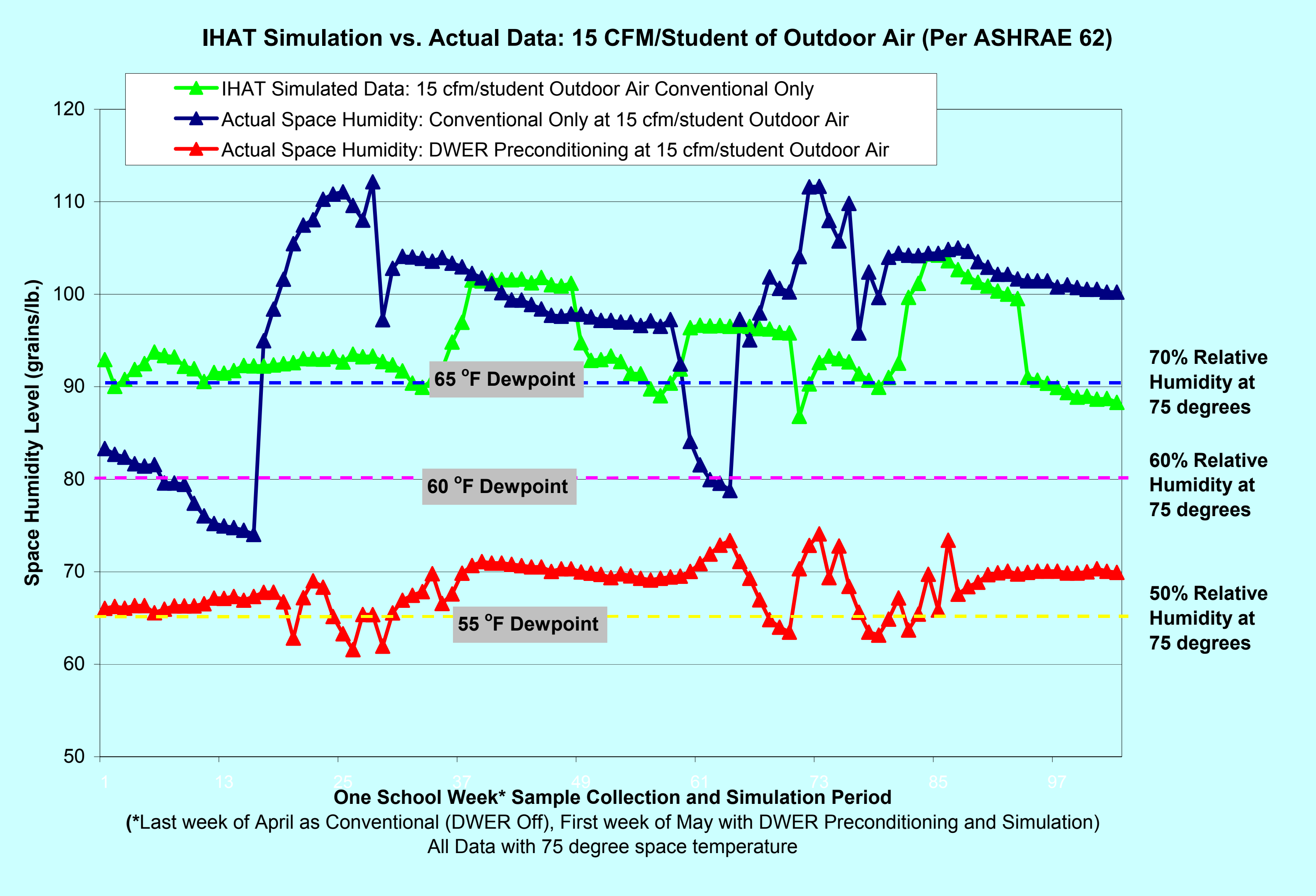
GTRI

VOCs With & Without Desiccant Operating



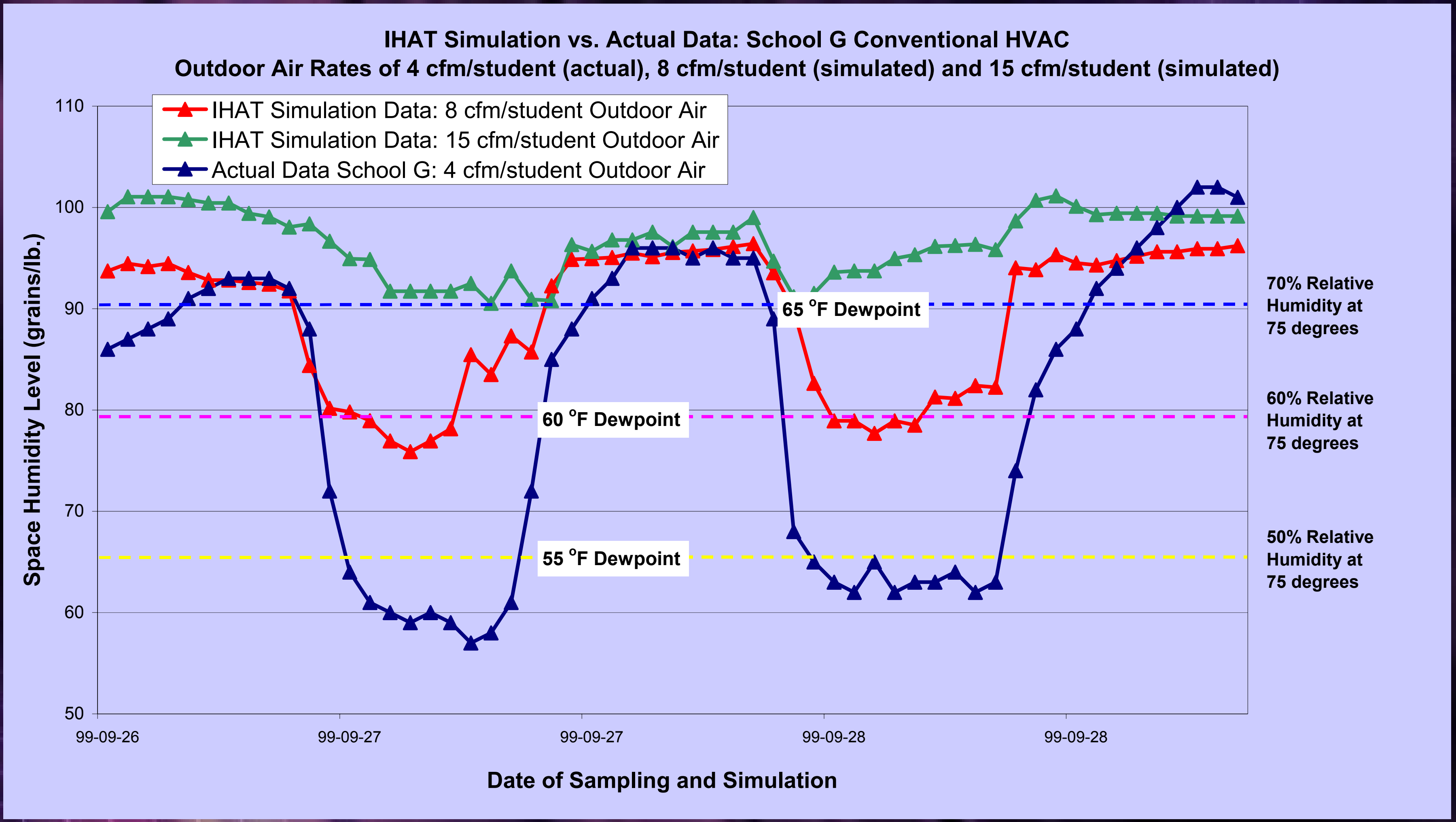
GTRI

Humidity Level vs Ventilation Rate Modeling



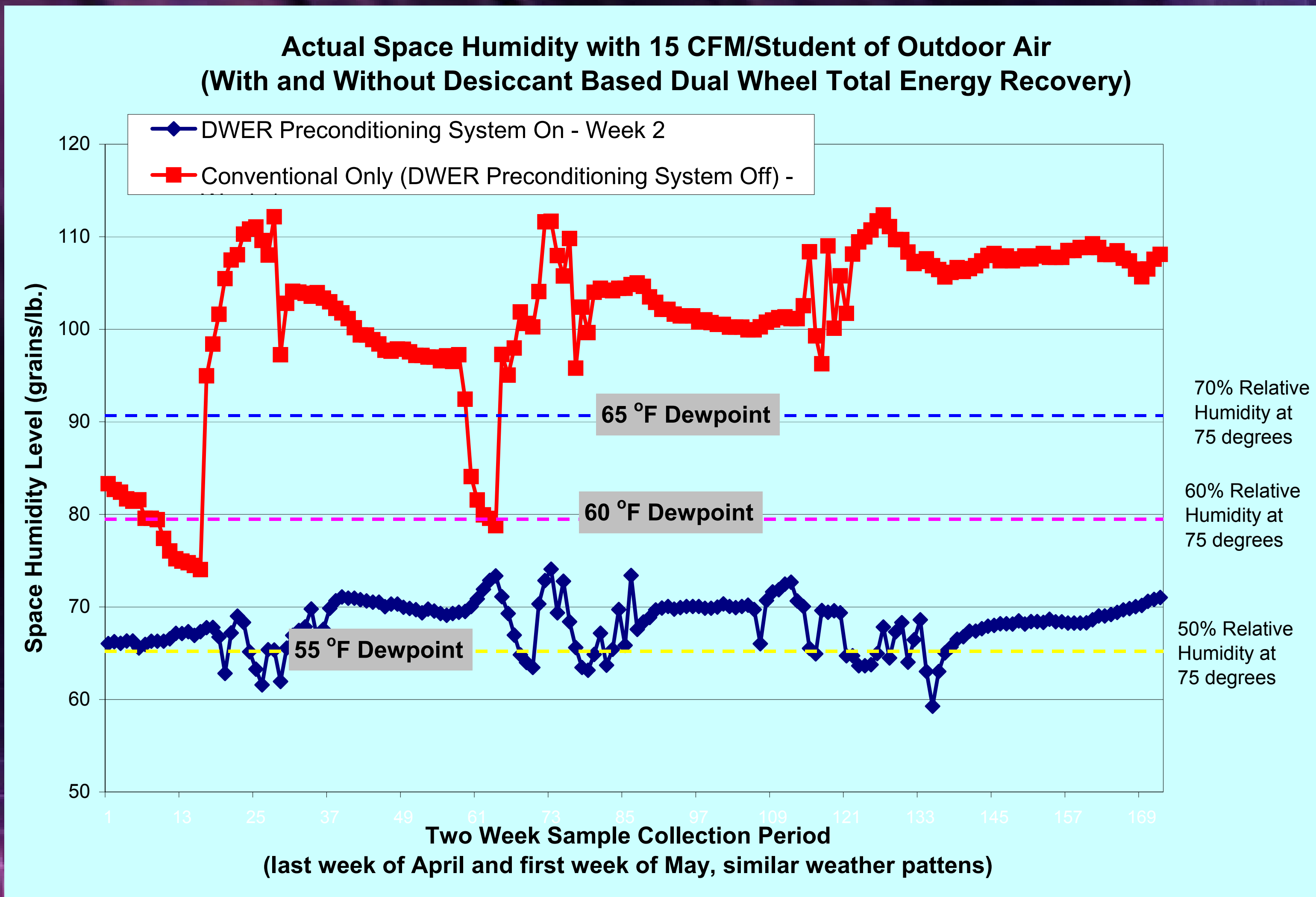
GTRI

Humidity Level vs Ventilation Rate Modeling



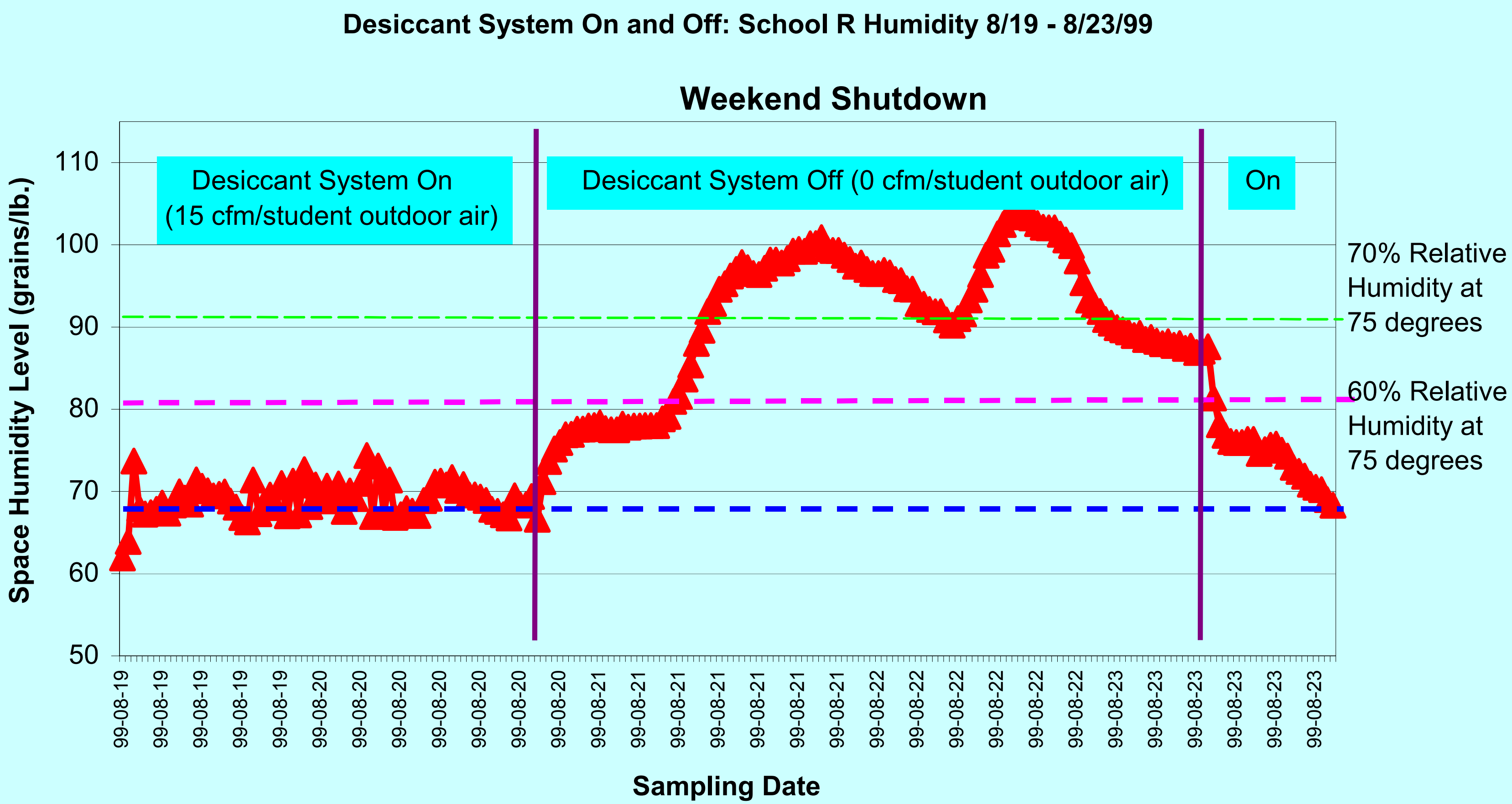
GTRI

Space Humidity with and without Desiccant



GTRI

Effect of Weekend Shutdown



GTRI

Student Absenteeism Data

School	Percent Absent											
	Nov98	Dec98	Jan99	Feb99	Mar99	Apr99	May99	Aug99	Sep99	Oct99	Nov99	Avg
A	5.30	6.00	6.90	6.90	7.30	7.30	7.80	4.20	4.20	5.60	5.60	6.10
J	3.60	4.10	4.90	4.90	4.80	4.80	4.80	2.80	2.80	3.70	3.70	4.08
E	4.24	2.20	4.05	6.11	5.72							4.46
R	3.19	2.46	2.55	4.80	4.31							3.46
L	5.39	5.70	7.92	6.57		6.26	6.75		3.48			6.01
P	4.85	3.17	6.35	6.66	6.04				1.29			4.73
G	2.76	2.89	3.49	3.65		3.81	3.55					3.36
U	3.91	4.61	4.67	3.30	3.35	4.17	4.92	2.07	2.46	3.06	3.15	3.61

GTRI

Important Findings

- Project Goals Met
  - ✓ Measured importance of humidity control & ventilation on school indoor air quality
  - ✓ Developed baseline of indoor air quality data for schools in hot & humid climates
  - ✓ Provided data & recommendations for more energy efficient HVAC designs for improving indoor air quality in schools
  - ✓ Documented role of desiccant technologies to actively control humidity in schools
  - ✓ Provided data for school systems to justify specification of desiccant systems

GTRI

Important Findings

- Found statistical significance of the importance of adequate ventilation demonstrates the importance of HVAC system design integrating desiccant cooling systems with conventional HVAC system components

- Demonstrated the importance of design for the integration of desiccant systems with conventional HVAC system components

- Demonstrated the importance of training for building specifiers & contractors and for facility maintenance staff on the purpose and operation & maintenance of desiccant technologies

GTRI

Importance to Integrated Energy Systems Program

- Meets goals to improve energy efficiency
- Justifies the "up-front" expense of using desiccant cooling technologies
- Demonstrates the importance of HVAC system design integrating desiccant cooling systems with conventional HVAC system components
- Shows the need for training of building contractors and specifiers and school facility and maintenance staff on the purpose and operation & maintenance of desiccant cooling systems

Publications

- Literature Review
  - www.ornl.gov/ORNL/BTC/iaq.pdf
- ASHRAE IAQ 2001
  - Presentation & publication in conference proceedings
  - November 2001
- International Conference on Indoor Air 2002
  - Accepted for presentation & publication in conference proceedings
  - July 2002
- Paper in ASHRAE Summer 2001 IAQ Newsletter
- Other publications in process

GTRI

Cooperative Efforts

- ASHRAE Proposal in Progress
  - Continuation to look at the impact of intervention technologies on school indoor environments and student health
- Joint Projects with Emory University Medical School
  - Investigate the impact of indoor environmental exposures on asthma
  - Development of the first generation of a real-time exposure & lung function monitoring system
- Joint Project with Semco Inc
  - Investigate the ability of a co-sorption wheel desiccant system to remove airborne contaminants from outside and recirculated supply air

GTRI

Cooperative Efforts

Co-Sorption Desiccant Wheel System

Market opportunity for active desiccant systems

Demonstrate that they have the ability to remove significant amounts of contaminants while simultaneously dehumidifying outdoor and building return airstreams

- **Research shows that 15% to 95% of many airborne gaseous contaminants can be removed.**
- **Contaminant removal efficiency varies depending on the individual contaminant (poor removal of ozone), the ambient humidity levels, and the regeneration temperature (higher removal at higher temperatures.)**

GTRI

Acknowledgements

This project was funded by the Department of Energy through Oak Ridge National Laboratories under contracts DEA C05840P21400 and 86X-SV044V and by Semco Inc.

The Research Team

Amy Cook

The Schools

Bob Hendry

John Fischer

Sid Crow Stephanie Hagen

GTRI